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INCIDENCE OF REMOVABLE PARTIAL DENTURE TYPES IN EASTERN WISCONSIN

by

Deo K. Pun, DMD, MS

A Thesis submitted to the Faculty of the Graduate School,
Marquette University,
in Partial Fulfillment of the Requirements for
the Degree of Master of Science

Milwaukee, Wisconsin

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ABSTRACT
INCIDENCE OF REMOVABLE PARTIAL DENTURE TYPES IN EASTERN WISCONSIN

Deo K Pun, DMD, MS

Marquette University, 2010

Aim: This study was designed to investigate patterns of tooth loss in patients receiving removable partial dentures.
Materials and Method: A point and shoot digital camera was used to collect 1502 digital images of cases at 5 dental laboratories in the eastern portion of the state of Wisconsin. Any case presenting to one the dental laboratories requesting a RPD was included. Two photographs were taken of each case. The first photograph was taken immediately upon arrival to the lab while the second photograph was taken immediately prior its first departure. A calibrated investigator analyzed all the photographs for Kennedy classification, type of RPD, major connectors, and other details
Results: Kennedy class I was the most commonly constructed RPDs at a frequency of 41%. In the maxilla, class III RPDs were the most frequently fabricated while class I remained the most common RPD in the mandible. 73% of the RPDs used metal frameworks, while the remaining 27% of RPDs used acrylic or flexible frameworks. The horseshoe major connector was the most common maxillary major connector while in the mandible it was the lingual plate.
Conclusions: Kennedy class I RPDs are still the most common mandibular RPD. However, the class III RPD is the most common maxillary RPD. 27% of all RPDs in this region utilized simple non-metallic frameworks which rarely met established design criteria. These numbers indicate a varying quality level of prosthodontic procedures provided in this region.

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Deo K. Pun, DMD, MS

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CHAPTER I

INTRODUCTION

Recent investigations have analyzed trends in demand for prosthodontics in the United States.[1,2] Over 90 years ago Hillyer pointed out that as the edentulous conditions decrease, the partial will increase.[3] Despite decreasing rates of tooth loss the need for removable prosthodontic treatment remains high.[4-6] It appears that a consequence of the professions improved preventive measures has been an increase in the number of patients who require partial prosthodontic treatment.[7] Likewise, an aging population retaining more teeth results in an increased number of teeth at risk for disease. Joshi and Manski evaluated some of the aspects of the more teeth more disease hypothesis.[8, 9] Conservative treatment modalities used to treat partial edentulism, such as dental implants also happen to be the most expensive. This continues to limit their availability to lower socio-economic groups in whom the highest rates of tooth loss occur.[10-12] It should not be a surprise then that conventional removable prosthodontic treatment modalities continue to outnumber implant tooth replacements in general practice.[13] Despite its frequency of use, the removable partial denture (RPD) receives minimal interest in the prosthodontic literature or at professional meetings.

Multiple RPD classification systems have been presented.[14-19] The Kennedy classification system is currently the system used in two prominent RPD textbooks[20,21] and was found to be the most commonly used system according to an older analysis.[19] The Kennedy classification system's main differentiating factor is its ability to quickly and clearly demonstrate the location of tooth support in relation to edentulous spaces. Due to its simplicity it does not make judgments regarding condition or position of the remaining teeth. The principles, concepts, and practices in prosthdontics (PCPP) states that a classification system should allow immediate visualization of the type of arch

being considered as well as immediate differentiation between tooth-borne and tooth-tissue supported RPDs.[22] More recently the American College of Prosthodontists (ACP) has formulated a prognostic diagnostic index that takes into account the many clinical factors which may complicate a particular case.[23] The ultimate goal of any classification system includes improved communication and consistency within the profession. Different classifications may also have associated treatment principles that assist in treatment standardization and teaching. If classifications are periodically analyzed the opportunity exists to compare their prevalence longitudinally.

CHPATER II

LITERATURE REVIEW

Kennedy Classification: existing demographic information

Several attempts to analyze specific trends in the prevalence of various types of RPDs have been presented. Most of these studies are of European populations. Anderson investigated the prevalence of the classification of RPDs at Birmingham Dental Hospital in the United Kingdom.[24] Out of a total of 417 RPDs, 208 (49.9%) were Kennedy Class I, 76 (18.2%) Class II, 101 (24.2%) Class III, and 32 (7.6%) Class IV. This was the earliest study of Kennedy classification prevalence. As a follow-up, Anderson's group reviewed another patient population to evaluate the type of RPD being worn.[25] Out of a total of 483 RPDs made, 302 (62.52%) had metal frameworks, 40 (8.28%) followed the 'Every' type of RPD design, and 141 (29.2%) were 'plate' RPDs. The 'Every' RPDs were all-acrylic resin frameworks occasionally incorporating retentive wire clasps. Plate dentures were also all-acrylic resin RPDs. However, while the 'Every' dentures consciously avoided covering gingival tissues the 'plate' dentures fully covered the cingulum areas of teeth. Another review at Birmingham hospital found that Class III RPDs were the most common RPD still in function among patients attending recall.[26] This may be due to better survival rates of Class III RPDs or biases introduced during the recall process. According to the information presented, only 38% of the patients recalled were examined. More recently, three commercial dental laboratories in the United Kingdom were surveyed resulting in examination of 80 maxillary and 44 mandibular cast metal framework RPDs.[27] The authors spent one day in each of the laboratories collecting the information. Kennedy Class III (69%) was the most frequent maxillary RPD while Class II was the most frequent in the mandibular arch (43%). Interestingly, the study was

repeated 10 years later for comparison purposes.[28] This time five commercial dental laboratories were surveyed for a total of 330 prescriptions and frameworks examined. Kennedy Class III (55%) was still the most common maxillary RPD, though the frequency decreased. Kennedy Class I was the most common mandibular RPD found. These differences may have been due to chance or possible changes in tooth loss and treatment selection.

Derry and Bertram recalled 65 RPDs made in Denmark after 2 years of service.[29] Nine of the original RPDs could not be recalled leaving 88% of the original RPDs to be examined. Of the recalled group, Kennedy Class III was the most frequent followed by Class I then II. These patients were all treated in a dental school environment and all received a cast metal frame RPD. Axéll and Öwall investigated the prevalence of RPDs in Sweden.[30] A clinical examination of 20,333 subjects aged 15 and over was conducted between January 1973 and October 1974. A RPD was found in 6.2% of those examined. Another study from Sweden reported that 14.5% of examined individuals had a RPD.[31] In this project a color photograph of the RPD was examined for 543 subjects ranging in age from 41 to 65 years. Information on remaining tooth distribution was also recorded, although the Kennedy classification was not used. Laine and Murtomaa surveyed 957 people in Finland to determine the frequency of different types of RPDs in people aged 15 and over.[32] Trained interviewers asked subjects if they were using removable dentures. The subjects were then asked to identify whether they were using a cast metal framed RPD or an acrylic resin RPD with the aid of a series of photographs. 6.3% of those interviewed claimed to be wearing a RPD. All-acrylic RPDs dominated the distribution with 70% of all maxillary and 61% of all mandibular. Another Finnish investigation by

Tervonen and colleagues sought the prevalence of edentulism and the frequency of removable dentures among 4 age groups.[33] 1600 subjects were examined by calibrated dentists, 400 subjects per age group. The frequency of RPD use varied by age group and was 3.2% in the 25 year olds, 9.1% in the 35 year olds, 9.5% in 50 year olds, and 7.0% in the 65 year olds. No distinction was made between RPD type and no discussion or analysis of tooth distribution was done.

Bergman's classic long-term follow-up consisted of 33 RPD patients in Sweden.[34] 2 cases were Class II and a single case was Class III. Of the 30 Class I RPDs, 25 were mandibular. All patients received cast metal framework RPDs and were placed on a yearly recall program. Yeung et al described the usage of cast metal frame RPDs in patients treated at a teaching dental hospital in Hong Kong.[35] Patients were recalled for clinical examination 5-6 years after placement. 100 out of 192 patients were constantly wearing their RPDs. Half of the prostheses were therefore no longer being worn. No dental maintenance program had been established. In contrast to some other evaluations, 127 out of 249 RPDs (51%) were Class III. Similar percentages were found in both arches. A study in Australia by Witherell and Smales recalled RPD patients from the University of Adelaide for examination in 1978.[36] While some were all-acrylic the majority of cases used cast metal frameworks. 64 out of the 86 patients treated in 1973 attended a recall appointment. Partials made up to the year 1966 were included meaning a single patient often had multiple RPDs in the total analysis. The authors noted how prostheses were replaced 4 times or more due to failure during this time frame. A total of 150 RPDs was thereby assessed. A distinct difference between maxillary and mandibular

arches was seen. 60 out of 86 mandibular RPDs were Class I. 29 Class II and 21 Class III maxillary RPDs were found from the total of 64.

Several interesting demographic analyses were also made in Middle-Eastern populations by Keyf,[37] Sadig and Idowu,[38] and Al-Dwairi.[39] Keyf surveyed 528 RPD frameworks from 362 patients in Turkey.[37] The frequency of Kennedy Class I, II, and III RPDs were 43%, 38%, and 18% respectively. Surprisingly, they did not find Class IV RPDs. This was likely in part due to the fact that information was only collected for metal frameworks. Sadig and Idowu reviewed 650 work authorizations for patients in Saudi Arabia over the course of one year.[38] From these 650 work authorization, 422 total patient cases were analyzed. Transitional RPDs, and non-conventional RPDs were excluded. Therefore, only cast metal RPD frameworks were included in the analysis. The Kennedy classification was recorded for each case using Applegate's guidelines.[18] Class III RPDs were found to be the most common at 40.8% and Class IV the least at 5.9%. In the 319 patients with opposing RPDs, maxillary Class III opposing mandibular Class III was the most common at 22.5%. RPD frequency was also investigated among a Jordanian population.[39] Two hundred laboratory authorization forms from cases treated by 5th year dental students were collected over a period of 2 years. All-acrylic, transitional, and complex RPD designs were excluded leaving a total of 350 cast metal frameworks for analysis. Kennedy Class III with or without modification spaces was the most frequent at 47% on the maxilla and 45% on the mandible. Class IV was the least frequent pattern. 150 of the 200 patients had metal frame RPDs fabricated for both arches. It was also found that opposing Class III RPDs was the most common combination.

Several studies of this topic exist from the USA. Schwalm et al. recalled patients treated at the University of Washington one or two years after placement of a RPD.[40] All RPDs were made by dental students. Despite the short-term recall period 69 of the 161 patients who received a RPD were unable to be reevaluated. In this setting the Class I RPD was the most common followed by Class III and II respectively. All patients treated at this fee-for-service clinic received a cast metal framework RPD. Chandler and Brudvik followed up this group of patients 8 to 9 years after placement.[41] Only 38 patients with 44 RPDs attended the recall. Ten RPDs from this group were no longer being worn. Of those recalled Class I (55.8%) remained the most prevalent followed by Class II (32.4%) then Class III (11.8%). Curtis and colleagues surveyed the incidence of various classes of RPDs fabricated at a single dental laboratory in California.[42] Work authorizations of 400 patients were collected over 20 consecutive working days. 327 of the 400 work authorizations were included in the study. 40% of all RPDs were Kennedy Class I while 33% were Class II, 18% Class III, and 9% Class IV. While Class I RPDs were the most common mandibular RPD at 49%, Class II RPDs were the most common maxillary RPD at 38%. Information regarding type of major connectors and retainers used was also gathered. When this demographic information was compared to data from earlier analyses there was an increase in the incidence of Kennedy Class II RPDs. Due to the relatively small number of cases, differences in international treatment philosophies and other issues, some caution is noted in their conclusions.

Redford's group estimated denture use among the US non-institutionalized population 18-74 years of age using data acquired through the NHANES.[6] The grand scope of this project allowed examination of 7,374 subjects. 8% of the total examined

subjects were using a RPD. The prevalence increased with age to 22% at 55-64 years. This finding did not include all-acrylic RPDs. Using five commercial dental laboratories from different regions of North America Öwall and Taylor investigated the frequency of different types of RPDs.[43] Each laboratory was asked to provide details of 300 consecutive RPDs as they are prepared for shipping out of the laboratory. Details were recorded by means of 35mm slide photographs with a clear work order number. All prostheses classifying as RPDs were to be included. The photographs were either with the framework on the definitive cast or with the completed prosthesis alongside. 1,363 total case photographs were analyzed. While information regarding number of remaining teeth and some information regarding tooth distribution was presented; there is no mention of Kennedy classification. This makes comparison and analysis difficult. 95% of RPDs analyzed had cast metal frameworks. This percentage seems high considering clinical realities and general practice. No recent analysis of incidence or prevalence of various types of RPDs or Kennedy classification could be found for the USA.

Prevalence of RPD framework types: acrylic or metal

The few studies looking at RPD fabrication trends in the USA have looked at data pertaining to conventional metal framework RPDs. While this simplifies analysis of the framework design it may not give realistic data in regards to the treatment being provided to the majority of the population. While valid long-term outcome data is sorely lacking, all-acrylic resin RPDs continue to be used with great frequency.[44,45] It has been demonstrated in several other countries that all-acrylic resin RPDs are far more common than cast metal framework RPDs.[46-48] Lewandowska et al. reported on RPD frequency in

Poland.[46] 20 dental laboratories were questioned for type of prosthetic appliance being used. Of the 983 patients who received a RPD, half had one fabricated in both arches for a total of 1,418. 87% of the RPDs fabricated were all acrylic resin without a metal framework. It was highlighted that the socialized dental services in Poland provide this type of RPD for free as an alternative to the more expensive cast metal framework RPD. Thean surveyed the use of RPDs among 469 private dental practitioners in Singapore.[47] Only 172 (37%) responses were received. The study reported that residentially based practitioners recommended all acrylic resin RPDs for the majority of cases. Few town practitioners however recommended all acrylic resin RPDs. Due to the suspected high percentage of all acrylic resin RPDs fabricated by this group of providers it was not surprising that less than 10% stated that they conducted tooth preparations prior to the final impression. It was speculated that the frequency of all acrylic resin RPDs would have been higher if government providers were included in the survey. Radhi collected 131 written prescriptions from five dental laboratories in Kingdom of Bahrain over a period of 2 months.[48] 89% of prescriptions requested an all acrylic resin RPD. 109 of the 131 cases evaluated had the definitive cast made from an irreversible hydrocolloid impression. These definitive casts were created a minimum of 24 hours after the impressions were made. Prescriptions for immediate and transitional prostheses were included in the analysis. Schwarz and Barsby discussed the fact that many of the British dentists they surveyed were providing all acrylic RPDs for the National Health Service. They also referenced the dental estimates from the UK which showed a ratio of 1 cast metal framework RPD for every 7 all acrylic RPDs created.[49] Another recent analysis from the United Kingdom and Ireland was completed by Lynch and Allen.[50] While

reviewing aspects of RPD education they also reported the frequency of cast metal framework and all acrylic resin RPDs. A ratio of 3 cast metal frameworks for every 2 all acrylic resin RPDs was found in the 11 dental schools that responded. These numbers demonstrate the sometimes significant difference between institutionalized, government subsidized, and private practice treatment.

These various studies highlight several of the factors which help determine whether a cast metal framework or all acrylic resin RPD is fabricated. Insurance reimbursement, capabilities of dental laboratory support, and location and extent of missing teeth all appear to influence this decision. However, prosthodontic education may also play a role. While these studies are from other countries, it is suspected that similar factors play a role in the provision of selected RPDs in the USA. In addition, newer types of flexible acrylic or vinyl RPDs have received much attention in dental advertisement over the past decade. No recent peer-reviewed comparison of the prevalence of these different RPD framework materials could be found for the USA.

Framework concerns: comparison of acrylic versus metal

Without the established design principles and strength of cast metal framework RPDs it is believed that alternative RPD frameworks have reduced longevity and significant periodontal consequences. Occasional case reports or clinical tips have been published describing methods to improve the longevity of the all acrylic resin RPD. McCartney advocated the addition of wire rest seats to help prevent the tissue recession and inflammation caused by all acrylic resin RPDs using only soft tissue support.[51] Smith and Rymarz blended some of the benefits of cast metal frameworks with the

convenience of acrylic resin.[52] They recommended casting clasp assemblies only and then using acrylic resin to join these parts. The clasp assemblies were simply rests and clasp arms with a loop or beads for purposes of resin retention. It would seem that these efforts are undertaken due to poor clinical performance of acrylic resin. Studies by Zalataric,[53] Tuominen,[54] and Carlson[55-57] all investigated periodontal and dental health of RPD abutment teeth. Nearly all RPDs in these studies were acrylic resin without cast metal frameworks. It was generally found that teeth in contact with these acrylic frameworks were more likely to demonstrate dental disease. Zlatarić studied 205 patients wearing a RPD for a period of 1-10 years.[53] They found significant differences in periodontal health of abutment and non-abutment teeth and concluded that RPD design plays an important role. Tuominen reported that wearing a RPD significantly increased the odds of having periodontal pockets and concluded RPDs are a threat to periodontal tissue.[54] Similar to Zlatarić, 92% of subjects were wearing all acrylic resin RPDs with no mention of maintenance protocol. Wearing of RPDs significantly increased the odds of having deeper periodontal pockets. The authors therefore suggested that wearing of RPD is a threat to periodontal tissues. Carlsson published some of the earliest data on the condition of recalled RPD patients.[55-57] Many of these patients had been treated with complete maxillary dentures opposing an all acrylic resin mandibular RPD. The 13 year results of treatment confirmed the earlier assessment that all acrylic resin RPDs had a high incidence of fracture and or need for repair. After admitting that patients often had selected the all acrylic resin RPD due to economic reasons the authors concluded that it is poor economy in the long run to choose the cheaper construction.

In contrast to the available information regarding poor results of treatment with all acrylic resin RPDs it is interesting to note that several studies with positive long-term clinical results utilized cast metal framework RPDs.[40,41,58,59] The authors concluded that there is no direct evidence of well made RPDs significantly contributing to periodontal disease. Bergman's 10 year follow up of 23 patients wearing such RPDs yielded fairly positive results.[58] Most of the RPDs were Kennedy Class I. Yearly maintenance visits and oral hygiene instructions were conducted for all patients. They concluded that if the RPD was well designed and oral hygiene was maintained, the RPD will not cause dental disease. Bergman has followed the same patient population up to 25 years.[59] 13 of the original RPDs were still functioning. A specific comparison of gingival health was conducted by Bissada.[60] While not covering tissue was the preferred method for prevention of gingival inflammation in RPD wearers, inflammation was greater when acrylic contacted the gingival tissue than when metal was used. These projects seem to confirm a preference for metal framework RPDs in terms of clinical performance and periodontal health.

Framework handling: laboratory communication and clinical practice

If metal frameworks are preferred one must consider that modern RPD framework fit continues to be less than ideal.[61-65] Since the profession adopted Akers one-piece RPD casting technique in 1925 dentists began to rely more heavily upon dental laboratories.[66] With time it appears that the average practitioner understands less of the RPD framework creation process than previous generations.[67,68] There is an apparent trend that USA dental school curriculums have reduced time spent on removable prosthodontic

education.[69] There is concern this decrease in educational focus will have an effect on the quality of care provided by general practitioners.

The quality of communications with the laboratory has been reviewed consistently over the past several decades. Sykora and Calikkocaoglu sent identical casts to multiple commercial dental laboratories in order to compare and analyze designs for an extracoronal RPD.[70] No instructions were given to the laboratory except for a letter explaining the purpose of the project. 25 different laboratories returned a framework. According to the authors a remarkable variation in designs was received. While tendencies were evident for major connectors and certain clasp assemblies, some labs did not use a surveyor and some designs were unsatisfactory. This finding was similar to that of McCracken's survey of design of a mandibular RPD.[71] Frantz published two reports on design variation among dentists.[72,73] In the first, 97 dentists with varying experience were asked to submit their ideal design for a RPD for a Kennedy Class II modification 1 maxillary diagnostic cast. The responses included 96 different designs. In the next project Frantz had 57 dentists examine a patient with a Kennedy Class II modification 1 maxillary arch prior to prescribing their ideal RPD design. Radiographs and casts were available for all dentists. Despite the in-depth information, 57 different designs were still received.

In an effort to see if time had improved consistency of RPD designs in general practice Basker and Davenport repeated their 1977 survey.[27,28] Existing cast metal frameworks and prescriptions were reviewed at 5 laboratories. They examined 330 prescriptions and frameworks. The study found 40.3% of the prescriptions from the dentists included the RPD design details. This was double the 21% found with this

information in 1977. While improvement was seen the authors noted that 60% of cases were still being designed by the laboratory. Schwarz and Barsby also investigated communication and the provision of RPD therapy in the UK.[74] They first published responses given to them by the laboratories themselves. Only 673 out of the 1858 (36.2%) metal framework RPDs were designed by the dentist. However, it was also interesting to note that only 4.6% of the casts reviewed by the laboratory showed any evidence of tooth preparation. 1,773 out of 1858 showed no evidence of tooth preparation. The authors note that most of the specific advantages of a cast metal framework RPD are lost if the abutment teeth are not appropriately prepared to receive it. The authors confirmed that there is a divergence between clinical practice and dental school instruction. Schwarz and Barsby then surveyed 605 practitioners through the mail.[49] It was found that 52% of dentists rarely or never used diagnostic casts. Only 51% had access to a dental surveyor while 34% of respondents have the diagnostic casts surveyed. 87% of respondents never or rarely prepared guiding plane surfaces while 56% rarely or never prepared rest seats. When asked how much time on average was spent in the provision of a RPD 213 out of 474 (44.9%) respondents said less than 1 hour. Another 231 out of the 474 (48.7%) averaged between 1 and 2 hours to provide a RPD. The remaining 30 averaged more than 2 hours. As mentioned previously, the authors discussed the fact that many of the dentists surveyed were providing all acrylic RPDs for the National Health Service. They also referenced the dental estimates from the UK which showed a ratio of 1 cast metal framework RPD for every 7 all acrylic RPDs created. The article also noted how practitioners are economically unable to spend more time to provide what is thought to be the standard of care due to the low reimbursement

rates for a RPD. Lynch and Allen investigated some aspects of the quality of written prescriptions and master impressions used for fabrication of prostheses in the United Kingdom and Ireland.[75] When the prescriptions for RPDs were considered alone, 84 of the 136 final impressions were made with alginate. Surprisingly, the minimum time between an impression and pouring of the definitive cast was 72 hours. Out of the 136 total RPD prescriptions, 28 were considered to be poorly written while an additional 40 had no written instructions at all. Exactly 50% of cases therefore were designed almost entirely by the laboratory. These findings correlate with those found by Radhi.[48]

Similar information has been collected in the USA. Taylor received questionnaires from 303 out of 488 commercial dental laboratories.[76] 78% of those responding designed the majority of RPDs sent to them. That same percentage of laboratories estimated that less than 10% of the mandibular distal extension definitive casts were of the altered cast type. The overall conclusion was that practicing dentists frequently use techniques that require minimum appointment time.

Cotmore et al. surveyed RPD treatment and framework design between two dental school classes that graduated 7 years apart.[77] There was a good response rate of 90% of the class of the ‘70s and 64% of the class of the 60’s. Some deficiencies in standard of care protocol were found. In contrast to the findings from Britain, the vast majority of respondents claim they communicate well with the dental laboratory. It was interesting to note that significant differences existed in treatment methods and design between the different classes. The authors indicate that this demonstrates the influence of educational techniques upon practice. Hardy and Stuart studied prescriptions from 11 dental laboratories believed to be near Howard University in Washington, D.C.[78] Work

authorizations, diagnostic casts, and definitive casts or final impressions were examined for 300 cases. They found 81% of dentists failed to provide adequate prescriptions. In addition, 57% of the prescriptions lacked any written detail for proposed framework design. 8% of cases sent the final impressions to the laboratory, in all of these cases the impression material was irreversible hydrocolloid. Authors also found that 67% of definitive casts were submitted as unacceptable for prosthesis fabrication due to voids or bleb in critical areas such as rest seats and retentive areas. Burns surveyed prosthodontic specialists in an attempt to discern what would be considered the standard of care for RPD design and fabrication.[79] 195 responses were collected at the 1987 American college of Prosthodontists Annual meeting. 66% used stock trays for RPD final impressions which matched the 66% that used irreversible hydrocolloid for the same. Laboratory prescriptions were used in a high percentage of communications with the dental laboratory. In particular, 90% wrote detailed descriptions of the RPD framework. It was suspected that respondents often used multiple methods of communication thus resulting in no responses of 100%. 98% of patients were appointed for a separate framework try-in appointment by this group. 78% of respondents used rigid frameworks with stress releasing clasp assemblies for distal extension cases.

Clinical outcomes: general population within the USA

With these potential explanations for poor quality prostheses it is a disappointment that clinical analyses of non-institutionalized treatment in the USA demonstrate a high frequency of defects. Two fairly recent articles looked at the same data set from the National Health and National Examination Survey (NHANES III).[6,80]

This survey evaluated 7,374 persons. Examiners were trained and calibrated. Of those examined, 1306 were using a RPD. Five criteria; integrity, tooth wear, presence of temporary material or adhesive, stability, and retention were used to gauge the quality of removable prostheses. A mere 36% of RPDs were free of defects. Frank and colleagues from the University of Washington studied whether RPDs made in community practices met the standards of design and fabrication.[81] The study involved only Kennedy Class I and II mandibular RPDs made during a five year period. 91 of 292 eligible patients were examined, 82 of which yielded usable data. Most subjects (128) declined to be examined. 8 categories of evaluation regarding design and fabrication were developed from the PCPP.[22] Inter-examiner reliability demonstrated the acceptability of the criteria. More than half (43/82) of the RPDs met 4 or fewer standards. 43% (35/82) of the RPDs were rated as clinically acceptable while 46% (38/82) could be made acceptable by modification. The remaining 9 required replacement. Previous to this study Frank conducted a survey of patients in the same dental plan and metropolitan area.[82] Only 40.3% of the patients were completely satisfied with their distal extension RPD. Fortunately, only 19.7% expressed some level of overall dissatisfaction with the RPD.

Statement of problem: purpose

Perhaps the poor quality of removable prostheses seen in the general USA population is in part due to the factors discussed. Further analysis of the type of prostheses requested, design instructions given, and quality of material provided to the laboratory would clarify some of the sources of defective RPDs. Considering the previously mentioned factors, a modern analysis of the incidence of various classes of

RPDs would be of interest. It also provides an opportunity to investigate some of the existing trends in non-institutionalized RPD services. The purpose of this study was to investigate patterns of tooth loss in patients receiving removable partial dentures (RPD). In addition, details regarding how this treatment is provided was collected.

CHAPTER III

MATERIALS AND METHODS

Five regional commercial dental laboratories (Nu-Art Dental Laboratory Inc. Wauwatosa; Capitol Dental Laboratory Inc., Menomonee Falls; Saber Dental Studio Inc., Waukesha; Badger Dental Laboratory Inc., Milwaukee; Lord's Dental Studio Inc., Green Bay) located in the state of Wisconsin, USA were chosen for data collection. These laboratories were selected based upon initial telephone survey of number of RPDs produced. The laboratories authorized collection of digital images for the study. The proposed study was approved by the Institutional Review Board (Protocol number HR-1887) of Marquette University School of Dentistry, Milwaukee, WI, USA.

Data was collected by the laboratories using digital photography. Any case presenting to the lab requesting fabrication of a RPD was included. For this study, a removable partial denture was defined as any prosthesis that replaces some teeth in a partially dentate arch; it can be removed from the mouth and replaced at will.[83] Two photographs of this case would then be taken. The first photograph was taken immediately upon receipt to the lab. The second photograph was taken immediately prior to its initial departure from the lab. In this way, a particular case could only be recorded once. In addition, repairs and relines were thereby excluded.

Images were standardized by use of pre-measured backgrounds. The 12" x 16" background was placed on the floor or similar open space. The contents of an incoming lab case box that was to be included were then placed upon this predetermined area. The contents could therefore include a prescription, impression, a dental cast, or both. If received articulated, the mounting rings were loosened to allow cast placement on the background. Hinge-type articulators were opened to allow photography of the casts from an occlusal direction. Lab prescriptions were placed flat with no creases. Personal

identifiers such as the patient and dentist name were blocked out prior to photography using blank pieces of paper. In this way the photographs could not reasonably be traced back to individuals. No other items were placed over the prescription so that all other written information could be viewed. With all items positioned a hand held point and shoot digital camera was used to take the first photograph. The camera was held directly above the background. Using the view screen to guarantee proper positioning, the edges of the pre-determined background were aligned with the edges of the camera view screen. No zoom was therefore required and image sizes would be standardized. The auto-focus feature of the point and shoot camera was used to guarantee proper visualization along with the auto-flash setting.

The second photograph was made using the same technique as the first only now all contents departing the laboratory were placed on the background. In addition to the previous contents this could now include a new cast, a metal framework, or a completed RPD. Frameworks being returned for trial evaluation were placed upon their definitive casts. If the definitive cast was destroyed during fabrication or processing the prosthesis was directly placed on the background polished surface up. The relation between the first and second photographs was maintained by relating the specific lab routing number which was given to each case and all of its contents upon arrival to the laboratory. This tracking number system was used by all labs in this study and this number stayed with this patient until the case was completed. The inclusion, exclusion criteria and this number method prevented repeat recording of the same patient case. For example, a case returning to the lab after altered cast impression would already have been photographed

during initial receipt to the lab and this could be confirmed by review of the lab tracking number.

Calibration of labs was conducted on two separate occasions, during the pilot study and again after study methodology was confirmed. Calibration consisted of describing the objectives and methods of the photography process to those making the photographs. After demonstration, the lab person in charge of photographing the cases was observed during one session of photographs to assure the technique described above was followed accurately. A single photographer from each lab was selected and trained; no other photographers were used during the study period. Once calibrated a summary of instructions was left for each photographer to reference (Figure 1). Since each lab has different receiving times established for in-coming cases, it was determined that photographs should be taken immediately upon opening of received case boxes. This assured that cases would not by-pass the initial photographs and be missed. For out-going cases, photographs were taken just prior to packaging.

Once study methodology was confirmed a minimum of 1 follow-up visit to each laboratory was conducted during the initial 2 weeks of data collection. Calibration of the photographer was confirmed, data was reviewed for accuracy, and camera maintenance was performed. Based upon the case volume during this first week camera maintenance was customized for each camera and each laboratory. Camera maintenance consisted of downloading of digital photos to clear the memory card, recharging or replacing batteries, cleaning the lens, and any other procedure required to continue efficient and accurate data collection. Data collection was planned to continue for a minimum of 4 weeks with a minimum sample size goal of 500 cases.

Fig. 1: Photographic instructions

Abbreviated photograph instructions

Receiving:

1. Open box, include all **new** RPD cases in project – see definition of RPD
2. Mark assigned # on Rx and Cast/impression to be seen on photo
3. Place all contents of case box within background provided
4. Cover patient and dentist names on Rx using block out paper provided
5. Use camera view screen to orient photo directly above background
6. Include background area only: No more, no less
7. Do not use zoom, leave focus and flash on automatic

Same case departure:

1. Use same photo technique
2. Include all items being returned to dentist in photo
3. Metal framework should be placed on cast if being returned for try-in
4. All **new** RPD cases are therefore photographed upon entry and departure

For this project a Removable Partial Denture (RPD) is:

Any prosthesis that replaces some teeth in a partially dentate arch; it can be removed from the mouth and replaced at will.

(Flippers, temporary RPDs, and odd-ball rem. appliances with natural teeth remaining should therefore be included.)

Do not include RPD repairs or relines

IF QUESTIONS OR PROBLEMS ARISE PLEASE CALL

Deo Pun @ MUSoD: (414)-288-6508

As photographed cases were received, the first and second photographs of each case were matched and then numbered as previously described. Once matched the first ten cases from each lab were viewed by three of the investigators[a-c]. Each investigator simultaneously and independently collected information regarding that case with the data collection form (Figure 2). After completion the three authors' forms were reviewed and compared for calibration purposes. Any final changes in data collection criteria or definitions were made at this time. Once agreement on data collection criteria were confirmed 10 new cases from each lab were independently reviewed by three of the investigators[a-c]. This group of data collection forms was tested for reliability and accuracy. In addition, the lead investigator[a] and data collector[b] selected and reviewed an additional 10 random cases. One week later these same cases were again reviewed and the data collection forms were compared to confirm repeatability.

The laboratory name, laboratory case serial number, and arch were recorded at the top of each form. Whether the definitive cast or impression to create the definitive cast was included in the box was determined from the initial photograph. The prescription was used as confirmation. In addition, the basic type of impression material used was visually determined to be either irreversible hydrocolloid or a 'rubber' material. Question 4 gathered information regarding the amount of design information given by the dentist in the prescription. In essence it was an attempt to determine the level of design input by the dentist and therefore how much decision making was delegated to the laboratory technician. The design information was obtained directly from the dentist's written prescription. If the written prescription referenced a design cast or design drawing this

Fig 2: Data recording form

Data Recording - Deo Pun, DMD - RPD incidence thesis

1. **Dental Laboratory:** Badger / Capitol / Lord / Nu Art / Saber
2. **Laboratory Serial Number:** _____ **Arch:** Maxilla / Mandible
3. **Lab received:** Cast Impression [Alginate] [Rubber]
4. **Prescription:**
   a. Design: _____ Multiple design input
   _____ Minimal design input
   _____ No written design input
   b. State of Return: Completed For Trial Evaluation
5. **Pre-prosthesis information:**
   a. Classification: _____ Modification Spaces: _____
   b. Total # of missing teeth: _____
   c. Distribution: Anterior only Posterior only Both Ant &Post
5. **Prosthesis information:** Notation: ____ Rest(s)? ____
   a. Type of RPD: Metal framework | | Yes
   Acrylic resin | | or
   Flexible (Valplast) | | No
   b. Total # of Prosthetic Teeth: _____ TBD
   c. Type of major connector:
   Max: A-P strap Palatal strap Palatal plate Horseshoe
   A-P Bar Palatal bar Other (Specify): _____
   Mand: Lingual bar Lingual plate Other (Specify): _____

was considered written information as well. Information from a design cast was not considered if there was no written notice of such information. This protocol was developed due to inconsistencies encountered during pilot data collection. Comparisons were made between the written prescription and the returned laboratory work to assist with this evaluation. Design input was considered to have four basic areas of information: major connector, guide planes, rests, and clasps. Data collection including other information was attempted during the pilot testing. While information beyond these 4 basic criteria is often required and/or helpful, it was not able to be consistently and reliably obtained. This was primarily due to the data collection method, differences in laboratory prescription forms, and the wide variety of design prescription methods used. The following three levels of design input were considered:

a) **Multiple design input**: At least 2 of the 4 basic areas of design were communicated via the written prescription.
b) **Minimal design input**: 1 of the 4 basic areas of design was communicated via the written prescription.
c) **No written design input** – 0 of the 4 basic areas of design were communicated via the written prescription.

The state of return of the prescribed prosthesis was recorded next. The RPD was considered completed if it was returned after processing and/or with all prescribed prosthetic teeth attached. It was considered returned for trial evaluation if it was returned incomplete. Lack of prosthetic teeth or certain components was considered incomplete. If helpful, the prescription was also used to confirm the state of return of the RPD in question.

Pre-prosthesis information was collected next. The Kennedy classification with appropriate modification space enumeration was listed according to Applegate's modifications.[18] In those instances where implants were present as part of the abutment layout, the implants were considered as abutments when considering the Kennedy classifciation.[84] Whether anterior only, posterior only, or both anterior and posterior teeth were missing was recorded. If assessment of missing anterior teeth was in question, anterior teeth were considered missing if the prosthesis consisted of a prosthetic anterior tooth. This avoided misrepresentation of large diastema's or spaces closed due to tooth migration. The total number of missing teeth was recorded. Third molars, fixed prosthodontic pontics, and closed spaces were not considered missing teeth. If an immediate prosthesis was requested on the laboratory prescription the total number of missing teeth was recorded based on the modified cast. Therefore, if an unmodified cast was sent to the laboratory the number of missing teeth were recorded from the information in the second photograph.

Information on the prosthesis itself was now recorded. The type of RPD was determined using information from the prescription and or visualization of the prosthesis itself. A RPD was considered to be a metal framework if the major connector was cast. The RPD was considered to be acrylic resin if the major connector was processed in acrylic resin. This type of RPD may or may not have included wire clasps, rests, or reinforcement. If a RPD consisted of a combination of metal components and acrylic resin the final decision was based upon the material used for the major connector. The flexible type RPD was determined mainly from the laboratory prescription. This selection was confirmed by visualization of non-metallic clasp assemblies or the differing

appearance of the vinyl-acrylic material. In addition, if a specific type of complex RPD was found a notation was made. For example; swing-locks were noted under metal framework. It was not expected that many of these types of RPDs would be seen and therefore a specific check box was not included. After framework determination, information from either photograph was used to determine whether or not a partial denture rest was present. A partial denture rest, as defined by the 8th edition of the Glossary of Prosthodontic Terms, is a rigid extension of a fixed or removable dental prosthesis that prevents movement towards the mucosa and transmits functional forces to the teeth or dental implant.[83] Therefore, an extension of the RPD onto either a prepared rest seat or over the occlusal or incisal surface of a tooth or dental implant was considered to meet this definition. Lingual plates, minor connectors, and clasp arms were not considered rests unless they involved an actual rest, rest seat, or they involved an occlusal or incisal surface. At that point they could also be described in terms of the above definition; "preventing movement towards the mucosa." Total number of prosthetic teeth was determined by counting the teeth present on the completed prosthesis. If only a metal framework existed the number of prosthetic teeth was either estimated based upon size and position of remaining teeth or recorded as to-be-determined.

The major connector was visualized and recorded. The expected types were listed using the frequency of major connectors in previous research. The visualized major connector was classified as that which came closest to one of the following definitions:

a) **Palatal strap:** a maxillary major connector having an anterior/posterior dimension of 13-20 mm that directly or obliquely traverse the palate and is

generally located in the area of the second premolar and first molar. This type of major connector leaves the anterior and posterior palatal surfaces uncovered.[83]

b) **Palatal plate:** a maxillary major connector that covers the palate completely or partially but extends posterior to junction of the hard and soft palates.[21,83]

c) **A-P strap:** a palatal plate type major connector with an opening in the middle.

d) **Horseshoe (U-shaped):** a maxillary major connector consisting of a band of metal running along the lingual surface of the posterior teeth and extending onto the palate to cover the entire rugae area.[21]

e) **Palatal bar (or A/P palatal bar):** a maxillary major connector characterized by being relatively narrow but of increased thickness while traversing the mid-palatal region.[83]

f) **Lingual bar:** a mandibular major connector located lingual to the dental arch with visible gingival tissue lingual to any anterior tooth.[83]

g) **Lingual plate:** a mandibular major connector contacting the lingual surfaces of all remaining anterior teeth.[83]

Less frequent designs were to be listed as other with a written description if discovered.

After establishing reliability of data collection procedures the lead investigator completed review of the remaining photographed cases. Cases were organized digitally according to the previously mentioned lab initials and the serial numbers that were assigned to the case by each laboratory. Photographs were viewed digitally using an over head projector 92”x70”. Images were opened on-screen using a standard image viewing program (Microsoft Office Picture Manager). If helpful, the zoom feature of this

program was used in order to accurately collect all data. Any questionable or difficult to analyze photos were reviewed by the same previous three investigators to determine exclusion or inclusion. Once all information was transferred to the data collection forms these forms were tabulated using a computerized spread sheet (Excel, Microsoft).

[a] = Deo Pun
[b] = Michael Waliszewski
[c] = Kenneth Waliszewski

CHAPTER IV

RESULTS

Three investigators were evaluated using Fisher's exact test to analyze the accuracy of the data collection form. Similarly, Fisher's exact test was conducted to test the repeatability of the data collection forms of two investigators. The Chi-squared test was used compare the frequency of different Kennedy classification among three studies of RPDs incidence ($p<0.05$).

A total of 1502 images were received from the laboratories. Of these, 1140 images were matched photographs resulting in a total of 570 cases (N=570). Only these matched images were included in the study analysis. The remaining 362 individual images were excluded. Of this excluded total 347 images were unable to be matched and the other 15 were unmatched and unreadable. This was either due to errant omissions by the laboratory photographer or one of the two images being outside the time frame of data collection. Due partly to the ability to procure information from either of the two photos, none of the matching pairs of images had to be excluded.

Of the 570 included cases, 284 were maxillary and 286 were mandibular. The distribution of RPDs based on Kennedy Class is shown in Table 1. The most frequently fabricated RPD was Class I (41.0%) followed by Class III (28.6%), Class II (25.4%) and finally Class IV (4.9%). Class III's predominated in the maxillary arch (43.3%), while Class I's dominated the mandibular arch (55.6%).

The break-down of modification spaces for each classification are summarized in Tables 2-4. 60.2% of Class I RPDs lacked any modification spaces while only 23.4% of Class II RPD's lacked the same. 78.5% of Class III RPD's had either no or a single modification space indicating a large majority of either unilateral or single bilateral edentulous spaces. Overall, there were 268 RPDs fabricated without any modifications

Table 1: Kennedy Class distribution of RPDs.

Arches	Class I	Class II	Class III	Class IV	Total
Maxilla	75	64	123	22	284
Mandible	159	81	40	6	286
Total	**234**	**145**	**163**	**28**	**570**
Percentage	**41.0%**	**25.4%**	**28.6%**	**4.9%**	**100%**

Table 2: Kennedy Class I distribution with Applegate's modification.

Arches	**Modification 0**	**Modification 1**	**Modification 2**	**Modification 3+**	**Total**
Maxilla	42	23	10	0	75
Mandible	99	51	9	0	159
Total	**141**	**74**	**19**	**0**	**234**
Percentage	**60.2%**	**31.6%**	**8.1%**	**0**	**100%**

Table 3: Kennedy Class II distribution with Applegate's modification.

Arches	**Modification 0**	**Modification 1**	**Modification 2**	**Modification 3+**	**Total**
Maxilla	16	25	16	7	64
Mandible	18	40	20	3	81
Total	**34**	**65**	**36**	**10**	**145**
Percentage	**23.4%**	**44.8%**	**24.8%**	**6.9%**	**100%**

Table 4: Kennedy Class III distribution with Applegate's modification.

Arches	Modification 0	Modification 1	Modification 2	Modification 3+	Total
Maxilla	50	46	18	9	123
Mandible	15	17	8	0	40
Total	**65**	**63**	**26**	**9**	**163**
Percentage	**40.0%**	**38.6%**	**15.9%**	**5.5%**	**100%**

while 302 RPDs required at least one modification. According to Applegate's rules, a Class IV arch may not have any modification spaces.

Information regarding the Dentist prescription is presented in Tables 5 and 6. 47% of prescriptions were classified as having 'multiple design input', 16% as having 'minimal design input,' and 37% as having 'no design input'. 72% of cases requested return for trial evaluation prior to completion. 97% of metal frameworks requested return for trial evaluation. According to the images; 512 casts and 58 impressions were received at the lab (Table 7). The mean number of teeth replaced in this sample was 6. It was further noted that 47.4% of cases replaced posterior teeth only, 45.9% replaced both anterior and posterior, and 6.7% replaced anterior teeth only (Table 8).

Data on RPD framework details are presented in Tables 9-14. 73.3% of the cases were metal, 22.5% acrylic, and 4.2% flexible. According to the criteria discussed, 84% of cases were considered to have rests. Overall the horseshoe (72.5%) was the most frequently used maxillary major connector while the lingual plate (59.4%) was the most frequent mandibular major connector. Tables 12, 13 and 14 show the frequency of different major connectors among the different RPD material types. When analyzed separately nearly all (95.3%) non-metal maxillary major connectors were a horseshoe design. Likewise, nearly all (91.1%) of non-metal mandibular major connectors were a lingual plate.

Some additional findings of interest included 22 cases using attachments within some portion of the design or framework. One frame was fabricated from yellow gold. Four metal frameworks could not be classified based on the definitions used in this study. These cases presented as large Kennedy Class IV arches with remaining molars

only. These frameworks consisted of clasp assemblies over the molars (generally bilateral) and lengthy cross-arch meshwork extending along the lengthy edentulous span. 7 unilateral prostheses (Nesbit type) were also found. Four of the unilateral prostheses were made from flexible materials and three were metal.

Table 5: Prescription information on design input.

Design Input	**Overall**		**Metal Frame only**			
			Maxilla		**Mandible**	
	Frequency	%	Frequency	%	Frequency	%
Multiple	269	47.2%	109	61.6%	156	64.7%
Minimal	91	16.0%	20	11.3%	21	8.7%
None	210	36.8%	48	27.1%	64	26.5%
Total	**570**	**100%**	**177/418**	**42.3%**	**241/418**	**57.6%**

Table 6: State of return requested to the laboratories.

State of Return	**Overall Return**		**Metal Frame only**			
			Maxilla		Mandible	
	Frequency	%	Frequency	%	Frequency	%
Trial evaluation	412/570	72.3%	173/178	97.2%	233/240	97.1%
Completion	158/570	27.7%	5/178	2.8%	7/240	2.9%

Table 7: Materials received in the dental laboratories.

Lab received	**Frequency**	**Percentage**
Cast	512	89.8%
Alginate	5	0.9%
Rubber	42	7.4%
Unknown	11	1.9%

Table 8: Number of missing teeth and their distribution.

Missing Teeth	**Frequency**	**Percentage**	**Distribution**	**Frequency**	**Percentage**
1-3	110	19.3%	Anterior only	38	6.7%
4-6	207	36.3%	Posterior only	270	47.4%
7-10	218	38.2%	Both Ant & Post	262	45.9%
11-13	35	6.1%			

Table 9: Frequency of RPDs and usage of rest.

RPD type	Frequency	%	Rest – present	Rest – absent
Metal	418	73.3%	413	5
Acrylic	128	22.4%	35	93
Flexible	24	4.2%	0	24
Total	**570**		**448**	**122**
			78.6%	**21.4%**

Table 10: Distribution of major connectors according to Kennedy Classifications in maxilla.

Maxilla	Class I	Class II	Class III	Class IV	Frequency	Percentage
AP strap	8	8	8	3	27	**9.5%**
Palatal strap	3	13	11	0	27	**9.5%**
Palatal plate	9	3	2	2	16	**5.6%**
Horseshoe	54	39	97	16	206	**72.5%**
AP bar	0	1	1	0	2	**0.7%**
Unilateral	0	0	4	0	4	**1.4%**
Others	1	0	0	1	2	**0.7%**
Total	**75**	**64**	**123**	**22**	**284**	**100%**

Table 11: Distribution of major connectors according to Kennedy Classifications in mandible.

Mandible	**Class I**	**Class II**	**Class III**	**Class IV**	**Frequency**	**Percentage**
Lingual bar	65	34	12	0	111	38.8%
Lingual plate	94	46	25	5	170	59.4%
Unilateral	0	0	3	0	3	1.0%
Others	0	1	0	1	2	0.7%
Total	**159**	**81**	**40**	**6**	**286**	**100%**

Table 12: Frequency of different types of metal major connectors.

Maxilla	**Total**	**Mandible**	**Total**
Anterior Posterior strap	27	Lingual bar	108
Palatal strap	27	Lingual plate	128
Palatal plate	12	Unilateral	1
Horseshoe	107	Other	2
Anterior posterior bar	2		
Unilateral	2		
Other	2		

Table 13: Frequency of acrylic major connectors.

Maxilla	Total	Mandible	Total
Horseshoe	92	Lingual plate	31
Palatal plate	3	Lingual bar	2

Table 14: Frequency of flexible major connectors.

Maxilla	Total	Mandible	Total
Horseshoe	10	Lingual plate	10
Unilateral	2	Unilateral	2

CHAPTER V

Discussion

The laboratories were asked to provide consecutive RPDs until a minimum of 500 matched photographs were collected. Despite attempts at calibrating the sequence and

format of the photographs numerous images were found that did not follow the originally designed protocol. In particular, there were 362 unmatched photographs. Dental laboratories are busy places and it is not surprising that many cases were not photographed twice. One of the laboratories which provided most of the samples also had the most unmatched images. The most likely missing images were second photographs. In addition, it was strongly suspected that the written methods were not consistently followed. It was asked that the contents of the incoming case boxes be photographed as received. However, in several instances it was found that the lab poured up impressions to create a cast prior to taking the first photograph. It was also noted that the lab would often take the supposed 'incoming' photograph after completion of the case. Therefore, the first image in essence became the definitive cast without the framework in the image. This was discovered by the time stamp on the images as well as by the fact that many images had laboratory design drawings on the casts for the 'incoming' images. It was also suspicious that one of the dental laboratories only had images of metal frameworks. It is known that this lab does, on occasion create non-metallic frameworks. To have none of these within a three month time frame may be due to their decision to not include these. When the principal investigator inquired of the lab which provided only metal RPDs, it was admitted that only 3-4 non-metal RPDs were missed. The reason for these omissions and changes is suspected to be inadequate calibration and laboratory time constraints. If the explanation to the photographers had been improved they may have had a better understanding of what the purpose of the distinctly different images was. If a better explanation had been given and more time had been spent on preparation of the laboratory they may have realized that simply taking an image of the definitive cast

without framework was not sufficient to gather the planned data. One solution would have been to have the research investigators collect the images themselves. This was not considered logistically possible when using multiple laboratories. It was originally discussed that a single image would have been sufficient to collect certain data. This would have been easier for the laboratory but would have not been an attempt to gather information on the desired questions. With this in mind it is understood that the 347 accepted but unmatched images hold a great deal of reliable and usable information. They were not included in this analysis since they did not meet the original inclusion criteria but will be included in subsequent analyses. So while much of the data is usable it is admitted here that any data collected relying on the original protocol of two specifically timed images is not reliable and therefore should not be used for any definitive conclusions. This would include information on design input and what materials the laboratory received.

Since the data was collected at the laboratory only cases already in treatment were tabulated. Therefore, these numbers do not reflect the prevalence of RPDs or tooth distribution within the general population. However, by including all RPD types a broad picture of the partially edentulous population seeking this type of care was analyzed. Despite the previously mentioned methodological issues it is believed that very few RPD cases were not photographed at least once during this time frame. Since the major RPD producing dental laboratories in the Milwaukee area were all included. It is believed that the totals presented here are a reliable estimate of the metropolitan areas RPD fabrication incidence over the 4 month time frame of the data collection. Overall the encountered

limitations proved minor due to the large number of cases collected and the simplistic nature of the critical data analyzed.

For this study, a removable partial denture was defined as any prosthesis that replaces a tooth or teeth in a partially dentate arch; it can be removed from the mouth and replaced at will.[83] This was a much more strict use of the definition than previous analyses of RPD incidence which appear to have only collected data on metal framework RPDs. Despite this, Kennedy Class I cases continued to be the most common RPD configuration.[24,40-42] Class I was followed in order by Class III, Class II and Class IV. A nearly identical number of maxillary (284) and mandibular (286) cases were found. While it had previously been speculated that a greater number of mandibular RPDs was being fabricated due to difficulties with mandibular complete denture use, this was not found to be the case in this sample.[42] With dental implant use now a mainstream treatment alternative the fear of denture adaption may be reduced for those with the economic means to afford this alternative. In addition, improved knowledge regarding RPD success and treatment of dental disease may have encouraged maintenance of more maxillary teeth. It is interesting to compare the incidence of the various classifications to that discovered in other decades.[24, 42] The incidence of Class I RPDs found by Curtis et al. at a single regional dental laboratory in northern California in 1986 (40%) is nearly identical to that found here (41%). In contrast to that consistency is the increased frequency of Class III RPDs that was found. Curtis et al. found only 18% of the total cases to be Class III while 28.6% were in the current study. This increase was offset by a decrease in both Class II and Class IV cases in our data. Other major differences between the incidences of various classifications can be found when looking at specific

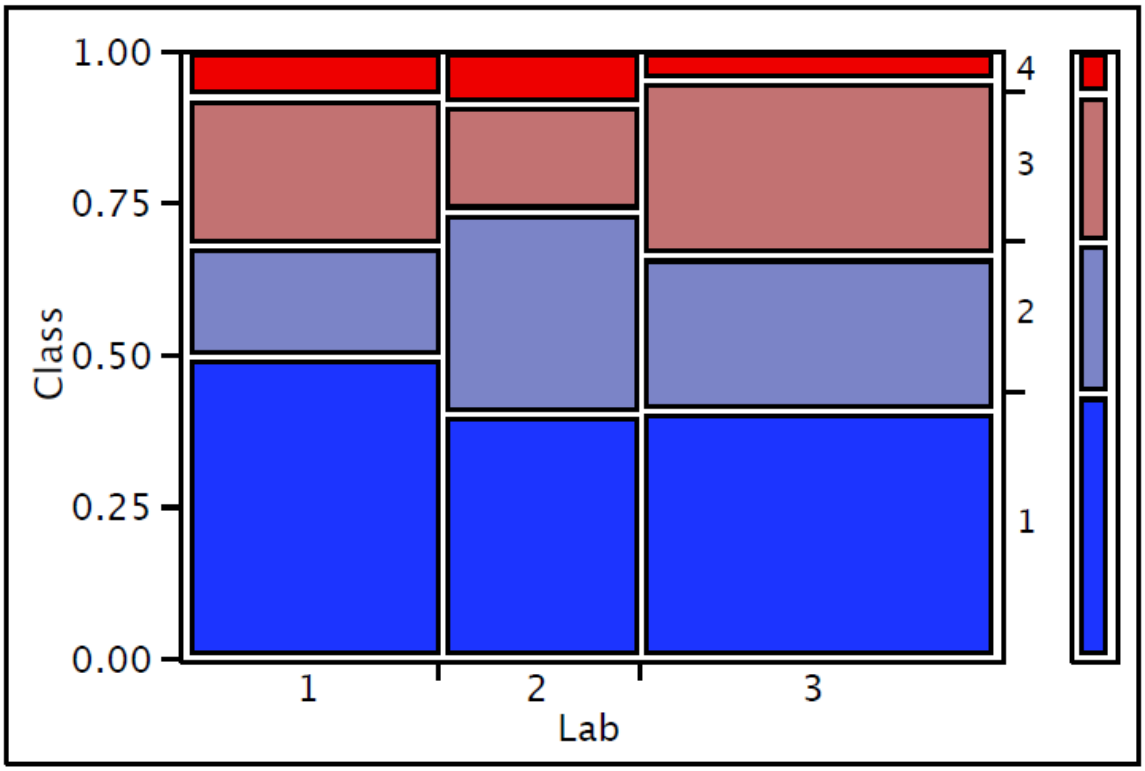
data sets. In the maxillary arch specifically, Class III was the most common. Signaling an increase in frequency compared to previous studies.[38,39,42] The increased incidence of Class III RPDs in the maxilla specifically and overall was probably related to the inclusion of acrylic and flexible RPDs. Whereas the even number of maxillary versus mandibular cases could be seen as a positive, the increased incidence of maxillary Class III cases (43.4%) compared to Curtis et al. (23%) may signal a lack of progress towards controlling dental disease or reduced economic ability of the patients to afford fixed replacements. It is felt that including all RPD types, non-metallic in particular, makes this study a more accurate reflection of the current demographics for this reason. The findings of this study also showed trend of increase in Class I and III RPDs while the opposite was true in Class II when compared to findings of Curtis et al. (Table 15 and figure 3). When metal RPDs were considered separately, the incidence of the classes followed the numerical orders from Class I to IV similar to previous studies.[24,42]

Beyond the Kennedy classification incidence, a broader analysis of tooth distribution was conducted. It was felt that those missing at least one anterior tooth are more likely to seek prosthodontic treatment than those only missing posterior teeth. Only 7% of the cases were missing only anterior teeth. 53% of the total cases were missing at least one anterior tooth. This difference was expected to be greater. Perhaps this is due in part to the fact that anterior teeth in general are maintained longer than posterior teeth.[2] It is also possible that these teeth are preferentially replaced by fixed prostheses. It also must be noted that the incidence of Kennedy Class IV cases was very small with only 5% of the total sample.

Table 15: Comparison of incidence of RPDs of overall and metal only with previous studies.

	Anderson et al.[24]		**Curtis et al.[42]**		**Pun et al. (Overall)**		**Pun et al. (Metal only)**	
Class	**Total**	**%**	**Total**	**%**	**Total**	**%**	**Total**	**%**
I	208	50.0%	132	40%	234	41.0%	195	46.6%
II	76	20.0%	108	33%	145	25.4%	122	29.2%
III	101	23.0%	59	18%	163	28.6%	82	19.6%
IV	32	7.0%	28	9%	28	4.9%	19	4.5%

Fig. 3: Comparison of three studies using contingency Mosaic table.



Note: Lab 1 – Anderson et al[24], Lab 2 – Curtis et al[42] and Lab 3 – Pun et al.

This study revealed that 73% of all RPDs were fabricated with cast metal frameworks. The remaining RPDs (27%) were fabricated with non-metal major connectors. These were made from either acrylic or flexible materials. The incidence of non-metal RPDs found in our study is much higher than the 5% found by Öwall and Taylor using similar inclusion/exclusion criteria in 1989.[43] However, this number is much less than that reported by several recent international studies.[46,48, 49] The high incidence of non-metallic RPDs found in this study was suspected. The laboratory which provided 45% of the total sample fabricates RPDs for Marquette University School of Dentistry. Only metal frameworks are fabricated by the dental school except in rare instances. It can be speculated that one laboratory who admitted not taking non-metal RPDs could have reduced the frequency of acrylic or flexible RPDs.

Despite the lack of comparative studies between metallic and non-metallic framework RPDs several major shortcomings of non-metallic RPDs exist. This material is often chosen for economic reasons but it is reported that it is poor economy in the long run to choose the cheaper construction.[55-57] This is primarily due to high rates of non-metallic framework fracture but may also be due to the reported soft tissue damage and potential for other periodontal complications.[53,54,55-57] The standard design feature meant to minimize soft tissue damage from RPDs is the rest. Despite our broad definition of a rest only 78.6% of cases used at least one rest. Therefore, 1 in 5 cases were completely tissue borne prostheses. When one looks at only non-metallic RPDs a mere 23% were considered to have at least one rest. Very often acrylic RPDs were given credit for a rest due to an embrasure style wire clasp extending across the occlusal surfaces of posterior teeth. Even though these were credited as a rest, 77% of non-metallic cases were

considered completely tissue borne. This evidence lends some insight to the frequent observation of periodontal tissue damage with these prostheses.

With the amount of advertising promoting flexible RPD frameworks it was somewhat surprising to find only 4% of these within the total sample. None of these cases were considered to have a rest of any kind. Perhaps this was due to the manufacturer claims of superior stability and retention of frameworks made from these materials. The authors were unable to locate any peer-reviewed or company sponsored research in regards to the clinical performance of these materials.

The majority of maxillary major connectors in this study (72.5%) fell under the definition of a horseshoe. A mere 27 (9.5%) palatal straps were found. In North America, one previous study found 56% of maxillary major connectors to be horseshoes while another did not find any.[42, 43] It is suspected that one study used the term anterior strap to describe a horseshoe type connector.[42] If this is in fact the case they found a mere 12.3% of their sample of this type. This demonstrates the necessity in clearly defining each major connector type as well as potential regional differences in RPD design. It is felt that the definitions used in this study were clear and easy to use. This statement is supported by the excellent accuracy and repeatability achieved by the calibrated instructors. There remains room for debate regarding the definitions. Our selected definition for a lingual bar was a mandibular major connector located lingual to the dental arch with visible gingival tissue lingual to any anterior tooth. This meant that a case that plated the canines but not the incisors was considered a lingual plate. Essentially, a lingual plate was required to cover the gingiva lingual to all remaining anterior teeth. Despite this, a majority of lingual plate major connectors was still found (59.4%). This is

much greater than in other research.[42,43] Part of the reason for the large majority of horseshoe major connectors and lingual plate major connectors was likely due to the material selection. Non-metallic RPDs generally require greater dimensions for adequate strength. Therefore, a bulky wide version of the horseshoe and lingual plate were selected nearly all of the time when non-metallic major connectors were used.

After attempting several different methods of collecting prescription information given by the dentist, a method similar to that used by Allen and Lynch was used.[75] Other methods left too much room for interpretation of drawings, writing, or the various prescription forms themselves. The accuracy and repeatability of our three choices was positive. By intentionally giving the dentist much credit for very little information we were still able to demonstrate how little input the majority of dentists have upon the prosthesis they are supposedly in charge of creating. 53% of the total prescriptions either did not provide any design information or prescribed one of the four components deemed necessary. It must also be noted that the cases from the lab servicing the dental school had a strong bias towards ‘multiple design input.’ This is because of the quality control procedures in place at the school. No case can be sent to the laboratory without a complete design, complete prescription form, and completed design cast with drawing. Considering that many of the cases from this lab were dental school cases the bias towards ‘multiple input’ was significant. Despite these limitations, the numbers and method still demonstrated a significant lack of design input by the majority of dentists. Many studies both old and new have highlighted this lack of prescribing dentist input as well as the varying RPD design philosophies.[70]

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study evaluated 570 pairs of digital images taken at 5 dental laboratories located in the state of Wisconsin, USA. Images were made of incoming and then out-going RPD cases only. The Kennedy classification according to Applegate's modification, major connector type, as well as other information was identified. The following conclusions were drawn from the study:

1) Kennedy Class I RPD is still the most commonly fabricated RPD.

2) Class I distal extension RPD was most commonly fabricated in the mandible (55.6%) while it was Class III RPD in the Maxillary arch (43.3%).

3) 73% of RPDs in this sample had a metal framework, while 27% utilized non-metallic frameworks.

4) Dentist prescribed multiple design input in 47% of the RPDs while 53% of the time no design information or only one of the 4 components was prescribed.

5) At least 20% of RPDs from this sample did not provide any rests.

6) The most common major connectors were the horseshoe for the maxilla and the lingual plate for the mandible.

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